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KRZYZANOWSKISAURUS, A NEW NAME FOR A PROBABLE ORNITHISCHIAN DINOSAUR FROM THE UPPER TRIASSIC CHINLE GROUP, ARIZONA AND NEW MEXICO, USA

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Abstract—Recent discoveries have demonstrated that *Revueltosaurus callenderi* Hunt is not an ornithischian dinosaur, so it is probably not congeneric with the putative ornithischian *Revueltosaurus hunti* Heckert. *Revueltosaurus* Hunt, 1989 is the senior generic name, so I propose here the generic name *Krzyzanowskisaurus* for "*Revueltosaurus*" *hunti*. Because the teeth of *K. hunti* appear more derived than *R. callenderi,* and are in fact more "typically" ornithischian than those of *R. callenderi*, I tentatively suggest that it does in fact represent an ornithischian dinosaur. Both *R. callenderi* and *K. hunti* have biostratigraphic significance. The former is an index taxon of the Revueltian land-vertebrate faunachron (lvf), and the latter is an index taxon of the Adamanian lvf. Indeed, the stratigraphic range of *R. callenderi* discriminates a discrete interval of Revueltian time (Barrancan) and that of *K. hunt* a subset of Adamanian time (St. Johnsian).

Keywords: *Krzyzanowskisaurus*, Triassic, ornithischian, Adamanian, St. Johnsian, Arizona

INTRODUCTION AND HISTORY OF STUDY

Archosauriform teeth (*sensu* Godefroit and Cuny, 1997) are among the most commonly recovered fossils from the Upper Triassic Chinle Group in the southwestern USA. Although the vast majority of these teeth pertain to phytosaurs, and are not identifiable below the level of family, a few, more unusual, morphotypes appear relatively distinct (Heckert, 2001, 2004). Among these are the teeth named *Revueltosaurus callenderi* by Hunt (1989) and *R. hunti* by Heckert (2002). Although these teeth are widely distributed across the Upper Triassic of the western US and easily recognized (e.g., Padian, 1990; Hunt and Lucas, 1994; Long and Murry, 1995; Hunt et al., 1998; Heckert, 2001, 2002, 2004), recent work (Parker et al., 2005; see also Hunt and Lucas, 2005) has demonstrated that *R. callenderi* is not an ornithischian, and instead is best assigned to the Crurotarsi (= Psuedosuchia of some authors and Crocodylotarsi of others) as a relatively basal taxon within that clade. Parker et al. (2005) did not designate a new genus name for "*Revueltosaurus*" *hunti*, nor did they specifically address its taxonomy other than to suggest that: (1) it is not an ornithischian dinosaur; and (2) based on an isolated squamosal from a locality known to yield teeth of "*Revueltosaurus*" *hunti* (UCMP V7308—see Fig. 1), that it is congeneric with *R. callenderi*. It is important to note that the biostratigraphic significance of *R. callenderi* as an index taxon of the Revueltian is unchanged by the discovery of Parker et al. (2005) as the new *R. callenderi* locality is stratigraphically essentially equivalent to the Dinosaur Hill locality (Fig. 1). Here I propose a new genus name for "*R.*" *hunti*, provide a list of synonymies, and discuss the evolutionary and biostratigraphic significance of the taxon. To this effect, I re-illustrate the holotype and paratype teeth of *Revueltosaurus callenderi* Hunt (Fig. 2), which remain diagnostic of the taxon, and much of the hypodigm of "*R.*" *hunti* (Figs. 3-6).

Institutional abbreviations: NMMNH = New Mexico Museum of Natural History and Science, Albuquerque; UCMP = University of California Museum of Paleontology, Berkeley.

SYSTEMATIC PALEONTOLOGY

Krzyzanowskisaurus, gen. nov.

Type species: *Krzyzanowskisaurus hunti*

Included species: Restricted to the type species.

Diagnosis: Same as for type species (see below).

Distribution: Upper Triassic strata of New Mexico (Los Esteros Member of the Santa Rosa Formation) and Arizona (Blue Mesa Member of Petrified Forest Formation).

Derivation of name: *Krzyzanowski*, for Stan Krzyzanowski, a lifelong devotee of Arizona's fossil record, for his many contributions to that record, especially in the Blue Hills where *K. hunti* teeth have been found; *-saurus*, Greek for lizard, hence literally "Krzyzanowski's lizard," understood to mean "Krzyzanowski's dinosaur."

Krzyzanowskisaurus hunti

Revueltosaurus callenderi: Long and Murry, 1995, p. 191, fig. 194.
Revueltosaurus hunti Heckert, 2002, p. 253, figs. 5-7, tabs. 3-4

Holotype: NMMNH P-29357, a nearly complete tooth crown (Heckert, 2002, fig. 5; Fig. 3).

Paratypes: NMMNH P-29358, nearly complete tooth crown (Heckert, 2002, fig. 6a-c; Fig. 4A-C); NMMNH P-29359, incomplete tooth crown (Heckert, 2002, fig. 6d-f; Fig. 4D-F).

Topotypes: NMMNH P-29347-29354, incomplete tooth crowns; UCMP V173839, incomplete tooth crown; UCMP V173840, incomplete tooth crown (Heckert, 2002, fig. 7a; Fig. 5a); UCMP V173841, incomplete tooth crown (Heckert, 2002, fig. 7b-c; Fig. 5B-C).

Referred specimens: UCMP V139563, incomplete tooth crown (Heckert, 2002, fig. 8d-f; Fig. 6d-f), UCMP V139564-139572, incomplete tooth crowns; UCMP V139573, incomplete tooth crown (Heckert, 2002, fig. 8a-c; Fig. 6A-C); UCMP V139574-139575, incomplete tooth crowns.

Etymology: After Adrian Hunt, for his extensive and diverse contributions to our understanding of Triassic paleontology, biostratigraphy, and biochronology, particularly with regard to early dinosaurs.

Type locality: NMMNH locality 1171, Santa Fe County, New Mexico (Fig. 1).

Type horizon and distribution: Los Esteros Member, Santa Rosa Formation, Chinle Group and Blue Mesa Member, Petrified Forest Formation, Arizona (Fig. 1). UCMP topotypes are from UCMP locality V92048, and UCMP V139563-139575 are from

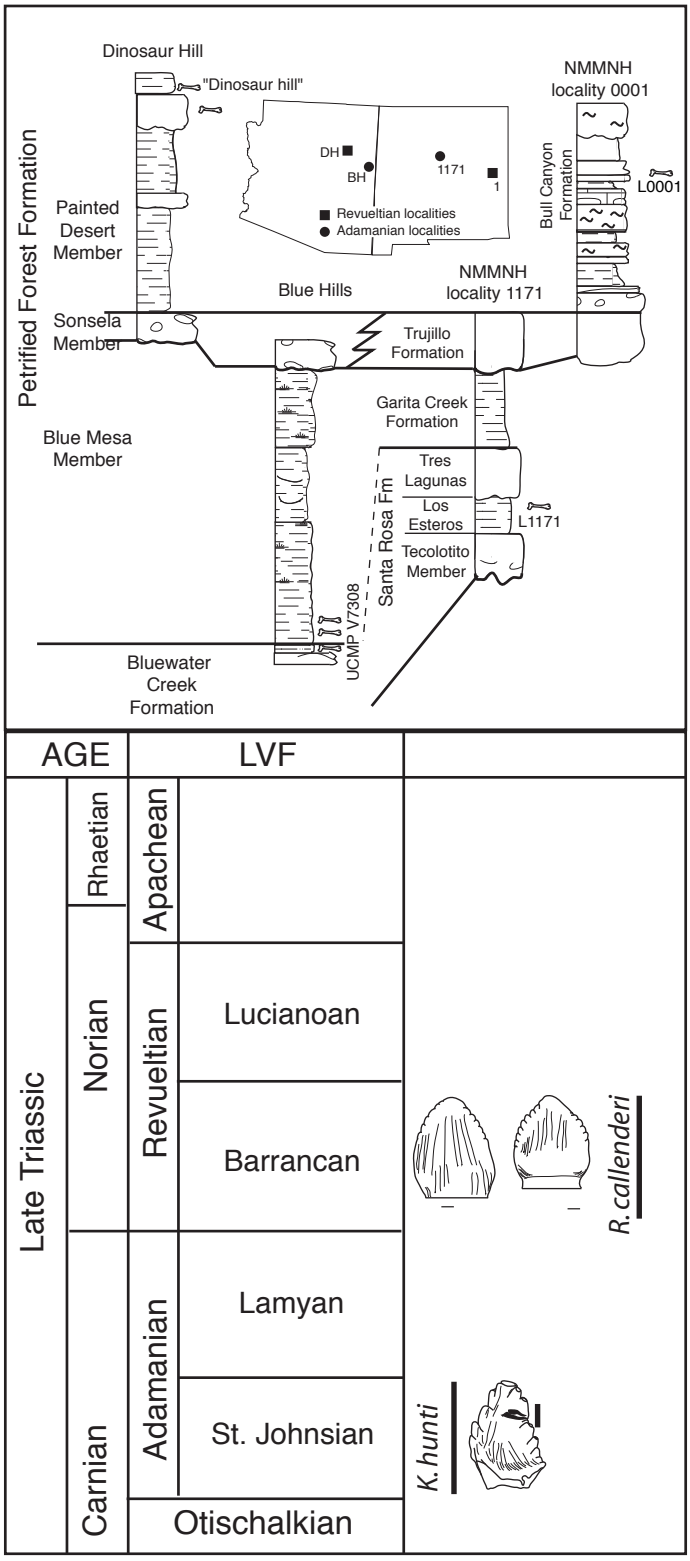

FIGURE 1. Geographic and stratigraphic distribution of *Revueltosaurus callenderi* Hunt and *Krzyzanowskisaurus hunti* (Heckert).

UCMP locality V7308 in the Blue Hills, east-central Arizona. Long and Murry (1995) erroneously listed this as locality UCMP locality 7307, and Heckert (2002) followed that assessment, but it is clear from sorting through the UCMP collections that *K. hunti* teeth are found in Camp's "meal pots" localities (UCMP 7308; Camp's field number 36/8), which yield a more unusual tetrapod fauna than UCMP 7307, which yields principally phytosaurs and metoposaurs.

Diagnosis: Archosauriform distinguished from *Revueltosaurus* by having posterior denticles that are slightly coarser and extend farther basally than the anterior denticles; denticles generally coarser (~1.5/mm, often ~1.0/mm); denticles coarsening basally; pronounced bulge on lingual surface resulting in a lingually concave outline in mesio-distal views; anterior denticles frequently offset lingually near base, occasionally with carinae bifurcating, resulting in basal denticles labial and lingual to the split carina; apex of tooth worn oblique to vertical axis of tooth (down to the labial side on lower teeth, down to lingual side on upper teeth, following Thulborn [1971b]).

These characteristics effectively differentiate *K. hunti* from all other Triassic and Early Jurassic archosauriforms, including the crurotarsan *Revueltosaurus callenderi*, all sauropodomorphs, and the putative ornithischians *Galtonia*, *Tecovasaurus*, *Pekinosaurus*, *Lucianosaurus*, *Technosaurus*, *Pisanosaurus*, *Fabrosaurus*, and *Heterodontosaurus* (Casamiquela, 1967; Bonaparte, 1976; Chatterjee, 1984; Hunt, 1989; Padian, 1990; Sereno, 1991; Thulborn, 1970, 1971b, 1992; Dutuit, 1972; Galton, 1978, 1986, 1990, 1992; Gauffre, 1993; Hunt and Lucas, 1994; Flynn et al., 1999; Heckert, 2001, 2002, 2004; Knoll and Battail, 2001; Harris et al., 2002; Knoll, 2002a,b). The fact that *K. hunti* possesses ornithischian synapomorphies (convergent with features of *Revueltosaurus*), particularly the expanded crown base, asymmetry in occlusal view, subtriangular outline in labiolingual views, and coarse denticles oblique to the tooth margin further differentiates it from theropods and sauropodomorphs (Hunt, 1989; Hunt and Lucas, 1994; Sereno, 1991, 1997, 1998, 1999; Novas, 1996; Benton et al., 2000; Langer, 2004; Galton and Upchurch, 2004).

DISCUSSION

Revueltosaurus callenderi was a notoriously difficult taxon to place in a phylogenetic context, and was considered a ?prosauropod (Hunt, 1988), an ornithischian (Hunt, 1989), a valid ornithischian or ornithischian "form genus" (Padian, 1990; Hunt and Lucas, 1994; Heckert and Lucas, 1996; Heckert, 2001, 2002, 2004; Hunt, 2001), as well as an ornithischian *nomen dubium* (e.g., Sereno, 1991; Norman et al., 2004). New material described by Parker et al. (2005) convincingly demonstrates that *R. callenderi* is instead a basal crurotarsan. As Parker et al. (2005) note, this was a surprising result, as most parties considered *Revueltosaurus* teeth ornithischian, even if they doubted the validity of the taxon, and it is important to reiterate here that Parker et al. (2005) affirmed that not only are the type specimens diagnostic of the species, but Hunt (1989) was correct in interpreting their position within the jaw (Fig. 2). Parker et al. (2005) then went on to cast doubt on almost all Triassic ornithischian records, accepting as valid only *Pisanosaurus mertii* (Casamiquela, 1967; Bonaparte, 1976) and a recently reported, but unnamed heterodontosaurid from Argentina (Báez and Marsicano, 2001). Although this hypothesis is certainly interesting, and would help explain the lack of convincingly ornithischian skulls and postcrania in the Triassic of North America, Europe, India, and Africa, I believe it is premature to discount other possible ornithischian occurrences generally and *Krzyzanowskisaurus* in particular.

In the case of *Krzyzanowskisaurus*, the teeth of *K. hunti* closely resemble the teeth of undoubted ornithischians from the Jurassic in their possession of expanded crowns that are relatively low in side view and asymmetric in occlusal view with denticles that are offset (sub-perpendicular) to the tooth margin and bear at least one well-developed cingulum. By current phylogenetic hypotheses, these teeth possess no fewer than five synapomorphies of the Ornithischia (e.g., Sereno, 1991; Hunt and Lucas, 1994; Heckert, 2001,

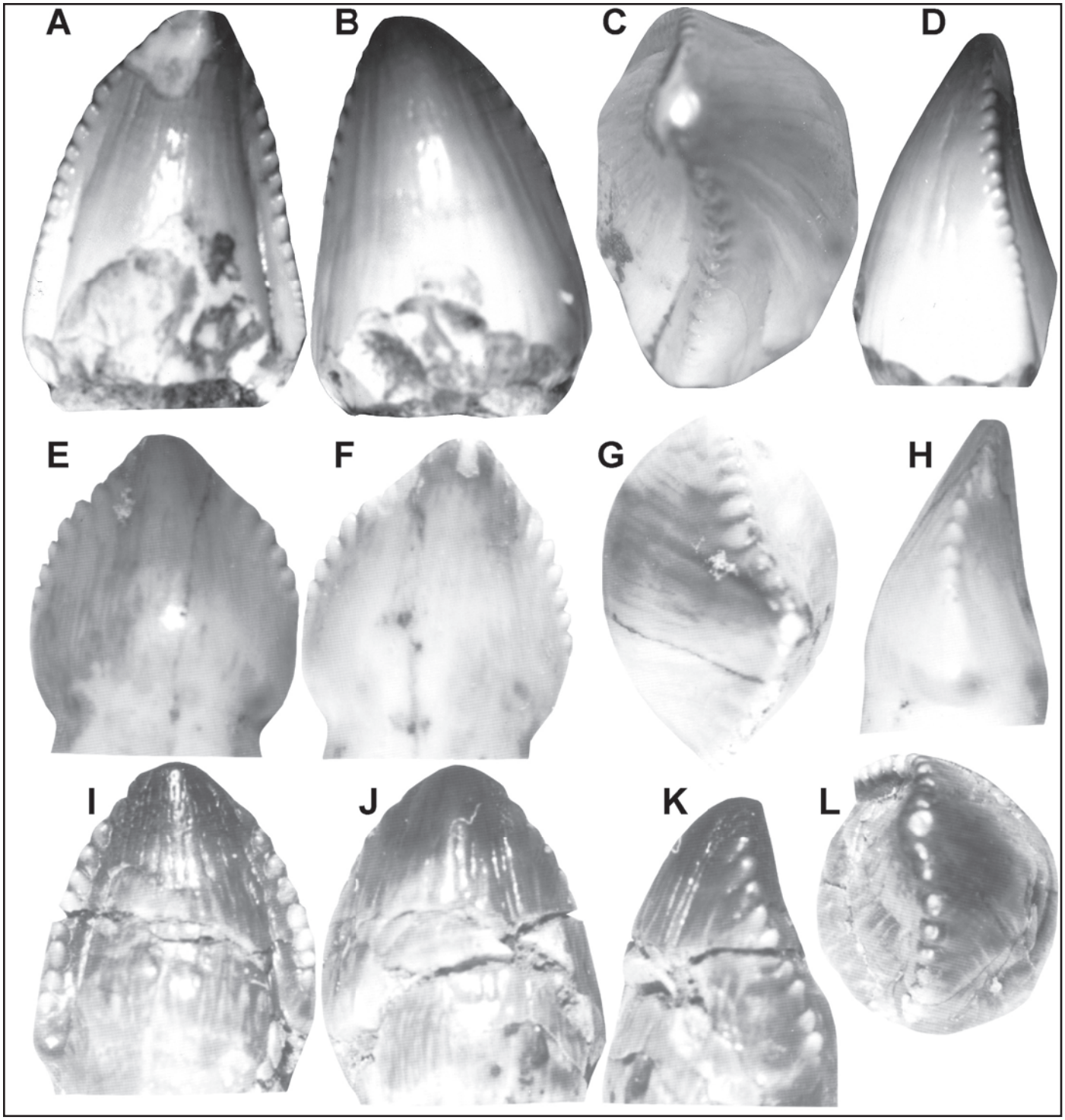

FIGURE 2. Paratype (A-H) and holotype (I-L) teeth of *Revueltosaurus callenderi* shown here for comparison with *Krzyzanowskisaurus hunti* (modified from Hunt, 1989, pl. 8E-H, pl. 9). **A-D**, Paratype premaxillary tooth of *Revueltosaurus callenderi* (NMMNH P-4959). **A**, Lingual view, x ~6. **B**, Labial view, x ~6. **C**, Occlusal view, x ~8. **D**, Mesio-distal view, x ~5.5; **E-H**, Paratype dentary / maxillary tooth of *Revueltosaurus callenderi* (NMMNH P-4958). **E**, Labial view, x ~7.5. **F**, Lingual view, x ~7.5. **G**, Occlusal view, x ~9.25. **H**, Mesio-distal view, x ~7.5. **I-L**, Holotype incisiform tooth of *Revueltosaurus callenderi* (NMMNH P-4957). **I**, Lingual view, x ~8. **J**, Labial view, x ~8. **K**, Oblique mesial-distal view, x ~8. **L**, Occlusal view, x ~7.5.

2002, 2004). It is important to note that several of these synapomorphies appear convergently in *Revueltosaurus*, but that simply indicates that these synapomorphies are no longer unambiguous synapomorphies of ornithischians. Thus, it appears likely that *K. hunti* represents an ornithischian. The alternative hypothesis is that *K. hunti* is a non-ornithischian archosauriform with individual teeth displaying an even higher level of convergence with ornithischians than *R. callenderi*, as *K. hunti* teeth possess a cingulum in addition to the other ornithischian features seen in *R. callenderi*. Neither hypothesis is particularly satisfying—if *K. hunti* is an early ornithischian, than the record of post-Adamanian Triassic ornithischians is especially poor. If it is a product of convergence,

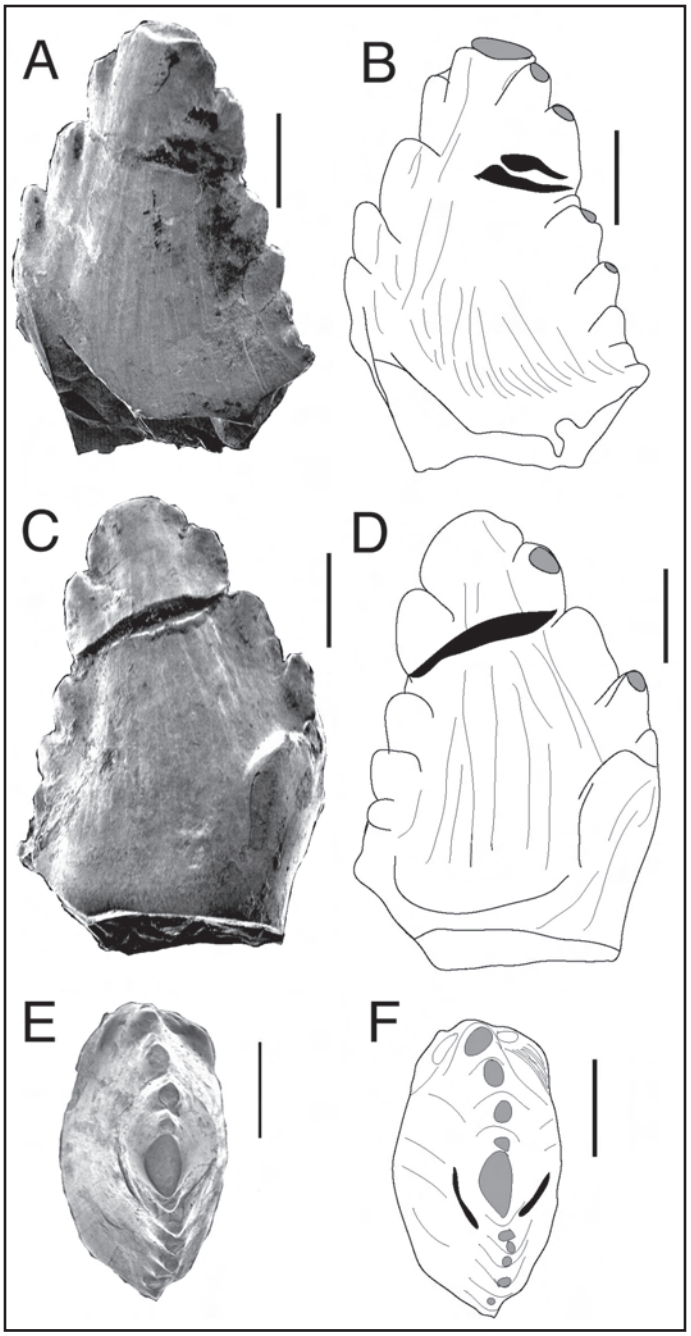

FIGURE 3. Scanning electronmicrographs (A,C,E) and interpretive sketches (B,D,E) of the holotype tooth (NMMNH P-29356) of *Krzyzanowskisaurus hunti* from NMMNH locality 1171. **A-B**, labial view, **C-D**, lingual view, **E-F**, occlusal view. Gray shading indicates wear, black shading indicates breakage. All scale bars = 1 mm.

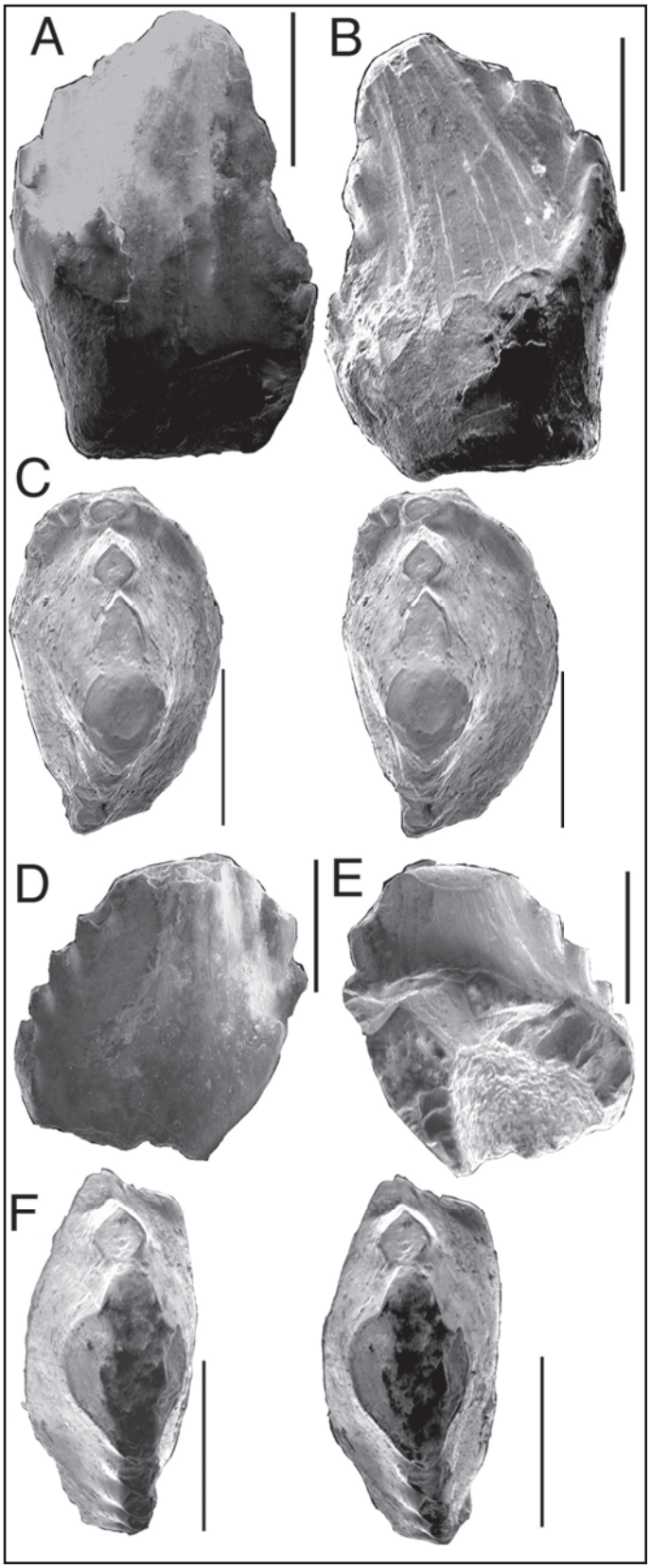

FIGURE 4. Paratype teeth of *Krzyzanowskisaurus hunti* from NMMNH locality 1171. **A-C**, NMMNH P-29358 in **A**, labial, **B**, lingual, and **C**, stereo occlusal views; **D-F**, NMMNH P-29359 in **D**, labial, **E**, lingual and **F**, stereo occlusal views. All scale bars = 1 mm.

than the utility of archosaur teeth to discriminate between taxa becomes even more problematic. Even if *K. hunti* is congeneric with *R. callenderi*, then, as Heckert (2002) proposed, the descent of *R. callenderi* from "*R.*" *hunti* stock requires significant simplification of the dentition from Adamanian to Revueltian time.

Regardless, I consider my own (Heckert, 2002) hypothesis of an anagenetic relationship between "*R.*" *hunti* and *R. callenderi* falsified, hence the new generic name. However, it is important to note that both taxa still have biostratigraphic utility. Indeed, with the ongoing attempts of various authors to further discriminate stratigraphic ranges of diverse Chinle taxa (e.g., Hunt et al., 2005;

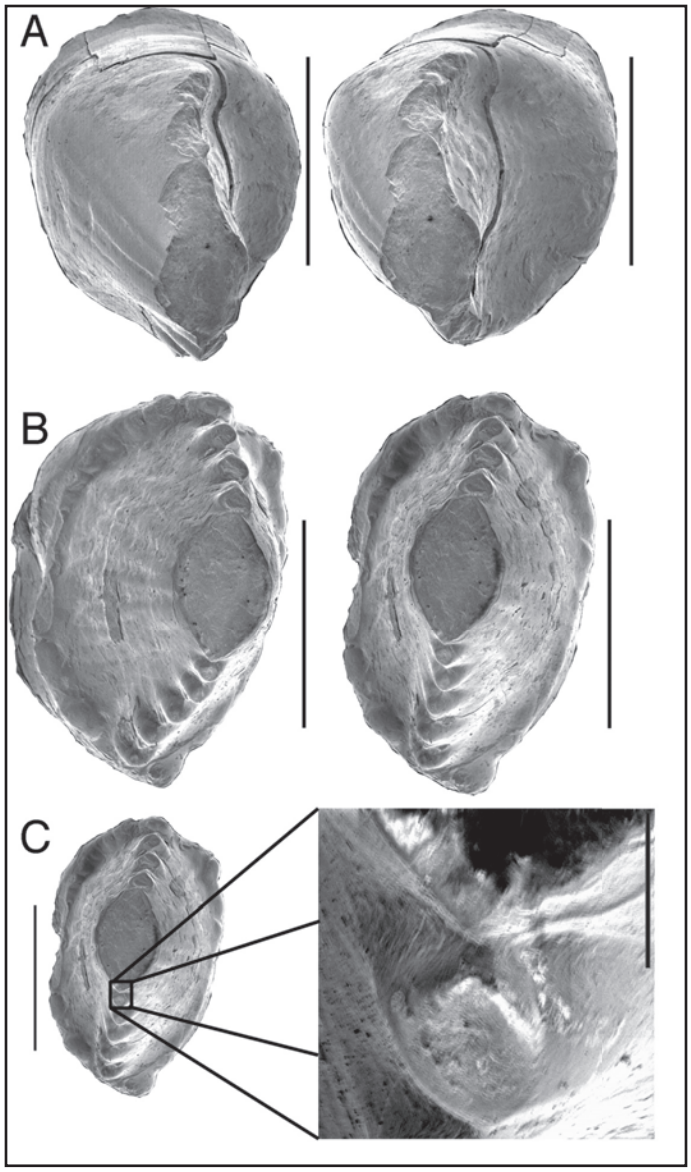

FIGURE 5. Topotype teeth of *Krzyzanowskisaurus hunti*. **A**, UCMP V173840 in stereo occlusal view, **B-C**, UCMP V139841 in **B**, stereo occlusal view and **C**, right image of (B) with close-up view of most apical posterior denticle showing wear facet and exposed enamel. All scale bars = 2 mm except for close-up of C = 200 microns.

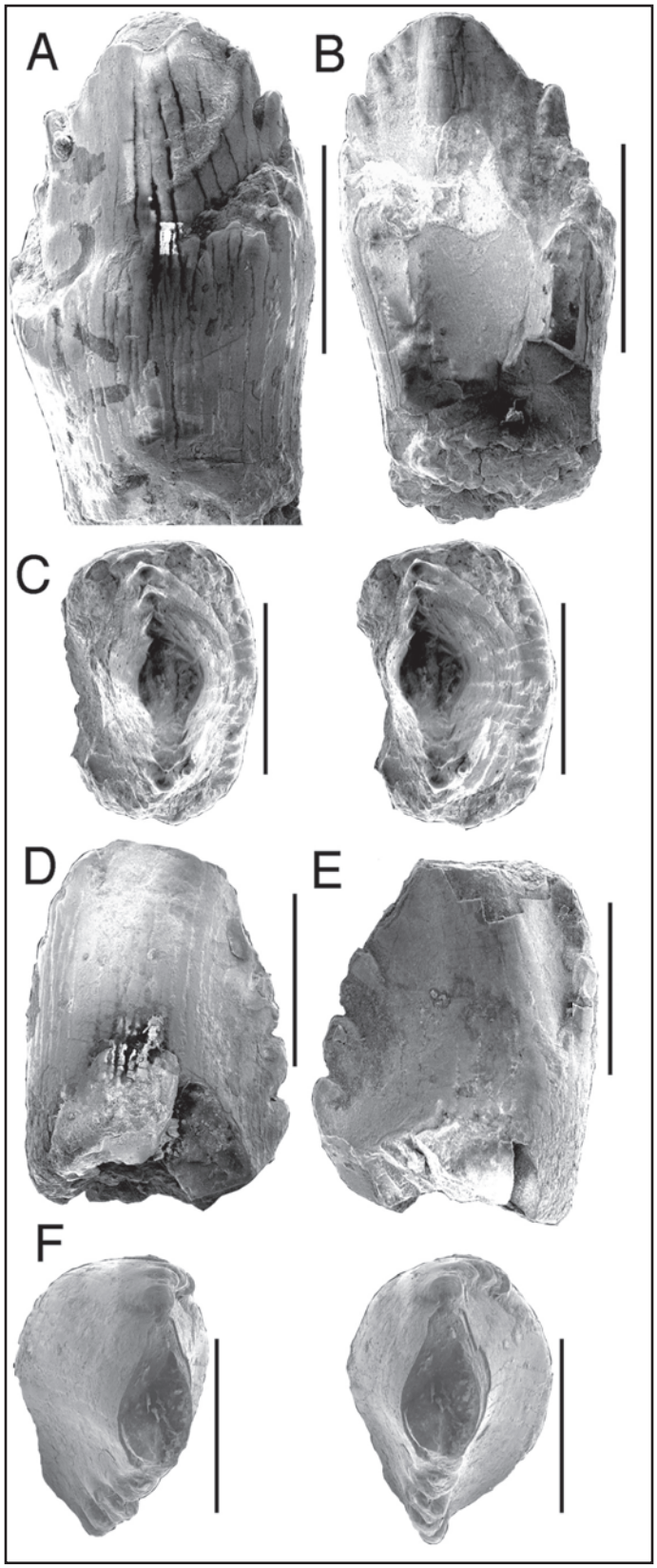

FIGURE 6. Referred teeth of *Krzyzanowskisaurus hunti* from UCMP locality V7307 in the Blue Hills, Arizona. **A-C**, UCMP V139573 in **A**, labial, **B**, lingual, and **C**, stereo occlusal views; **D-F**, UCMP V139563 in **D**, labial, **E**, lingual and **F**, stereo occlusal views. All scale bars = 2 mm.

Parker and Irmis, 2005) and the addition of new taxa, principally aetosaurs, with biostratigraphic potential (Lucas et al., 2002; Murry and Kirby, 2002; Zeigler et al., 2002; Parker, 2005), it is now apparent that there are more stratigraphically superposed first appearance data (FADs) than previously suspected. Consequently, Hunt et al. (2005) have proposed subdividing not only the Revueltian (as done by Hunt, 2001), but also the Adamanian. Hunt et al. (2005) recognize an Adamanian interval of time that can be subdivided into an earlier, St. Johnsian and a later, Lamyan sub-lvf. *K. hunti* is thus an index taxon of the St. Johnsian, as it is known from the Los Esteros Member of the Santa Rosa Formation (Hunt and Lucas, 1995; Heckert, 2002) and the Blue Hills of east-central Arizona (Long and Murry, 1995; Heckert, 2001, 2002). *K. hunti* is thus an index taxon of Hunt et al.'s (2005) St. Johnsian sub-lvf. Similarly, *R. callenderi* remains restricted to a relatively narrow stratigraphic interval in the lower Bull Canyon Formation (Hunt, 1989, 1994, 2001; Hunt and Lucas, 1994; Heckert and Lucas, 1997;

Hunt et al., 2005) and the lower Painted Desert Member of the Petrified Forest Formation in Arizona (Padian, 1990; Hunt and Lucas, 1994, 1995; Heckert and Lucas, 1997; Heckert, 2002). The new material documented by Parker et al. (2005) comes from localities stratigraphically equivalent to other Painted Desert Member localities yielding *R. callenderi* teeth. Consequently, *R. callenderi* is clearly an index taxon of the Barrancan sub-lvf of Hunt (2001; Hunt et al., 2005).

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